



## Cirrus Dopant

### *Nano-Composite Coatings*

Supports electrolytic & electro-less baths

Maintains coating functionality

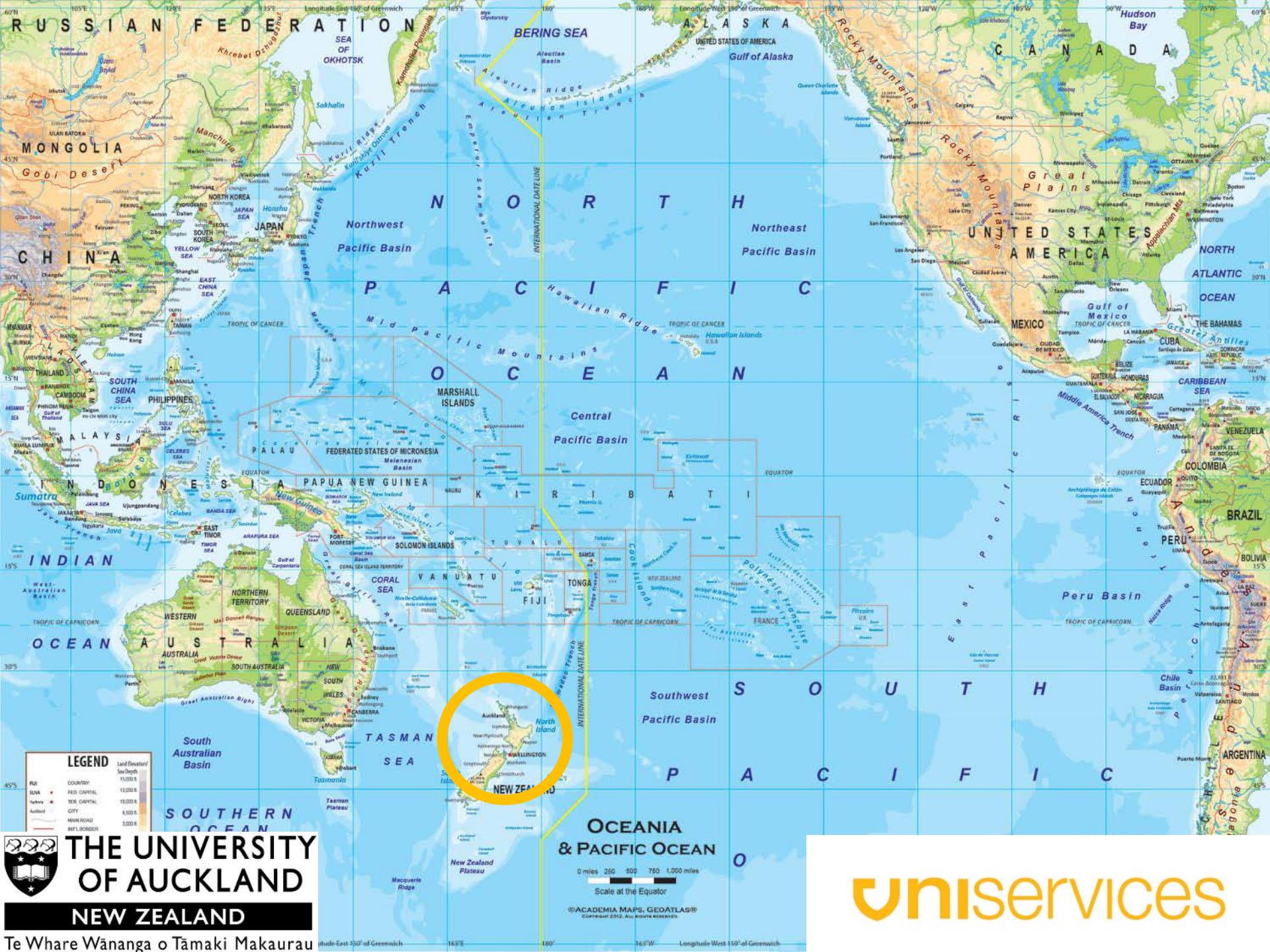
Adapts to a wide variety of coatings,  
substrates and finishes

No handling of nano-particles / powders

*A drop-in additive to standard plating baths that produces nano-composite coatings without alteration to the existing plating process.*

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## Plan



- Introducing Cirrus Dopant
- How it works
- What it does
- Development path

## Cirrus Dopant

- One-step additive for electrolytic/electroless
- Nano-particles form in the plating bath
- Nano-reinforced composite coatings with superior mechanical performance
- No handling of nano-powders or nano-materials





## Curiosity-led Discovery

- Challenge - create “metal-ceramic matrix” nano-composite coating?
- Addition of nano-particles as powder to plating bath:
  - Particle Agglomeration and Precipitation
  - Agitation & Time
  - Handling nano-particles in the environment



## Commercially-led Development

- Avoid expensive alteration to plating lines or standard processes.
- Be compatible with wide range of plating formulations and coating types.
- Easily adopted in both large scale manufacturing & in job-shops.
- Complementary to other coating improvement and nano-technologies.
- Ability to meet regulatory requirements.



## Investigate adjacent technology ...

- Nano-coating technology – sol/gel
- Aim to unify two well understood technologies
- Stopped trying to “add” nano-particles to plating bath.



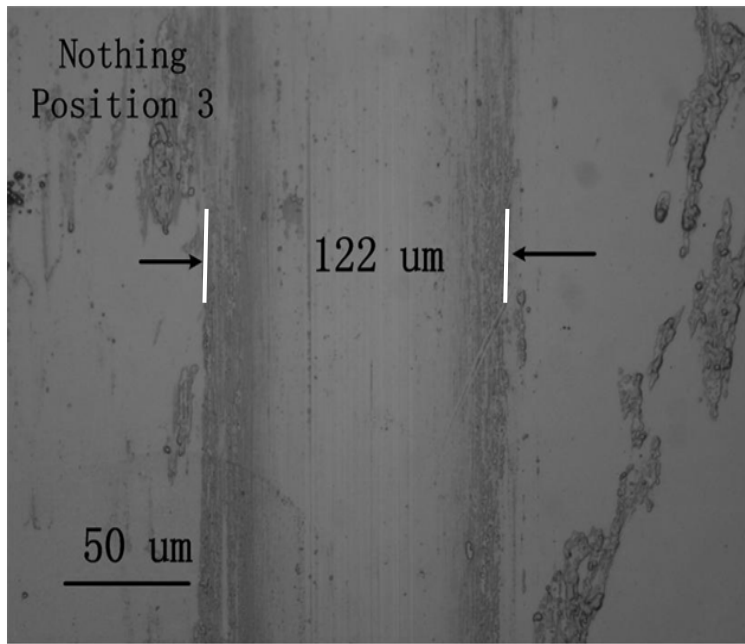




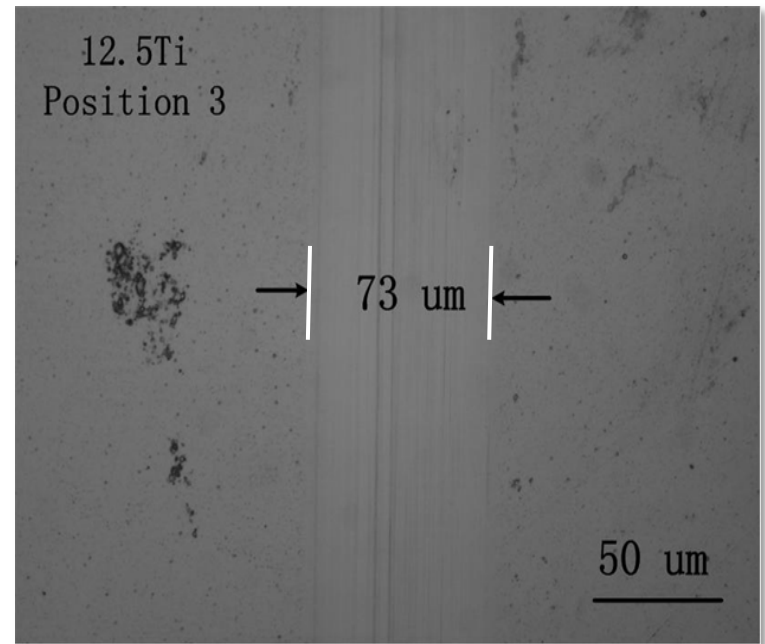
- 22k gold coatings
- Develop Ti dopant for decorative gold – pour in and plate
- Addition of <2% vol. dopant to produce 40% increase in wear & scratch resistance
- Smoother, less porous coating
- No change to conductivity, plating process, or coating appearance.

Focus on Au

22k Au – hardness 287Hv



Cirrus Ti doped 22k Au – hardness 356Hv

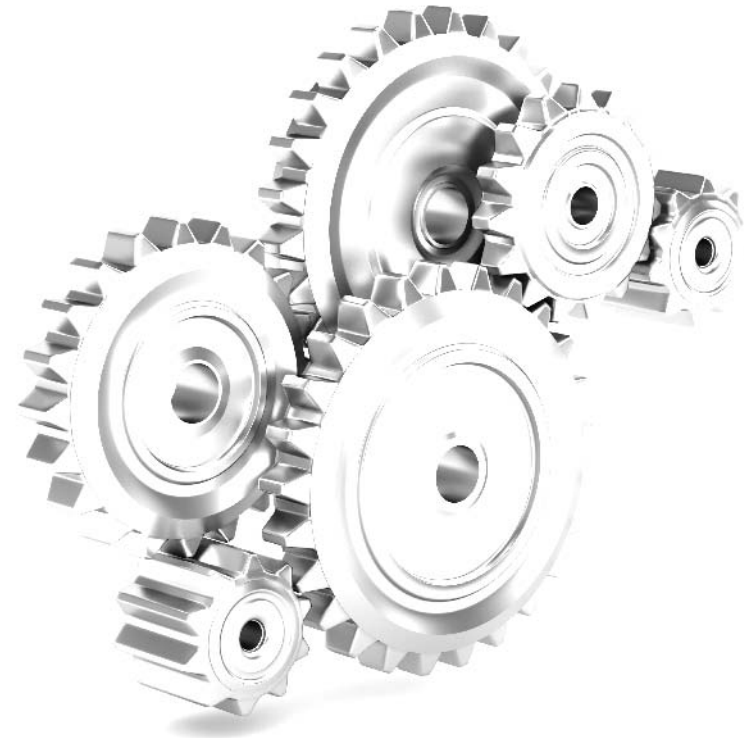


2 microns - 22k pulse plated Au on brass

Focus on Au

## How it works ...

- The first step is to understand the bath ...
- Particle creation process held in stasis until the dopant is added to the bath
- Determine addition, consumption, maintenance rates for each bath + dopant process
- Can be shipped by air freight, and is stable in storage at room temp for 3 to 6 months
- Nano-particles consumed more slowly than metals, so single addition lasts multiple metal turns
- Dispersion strengthening & grain refinement



## Cirrus Dopant R&D progress so far ...

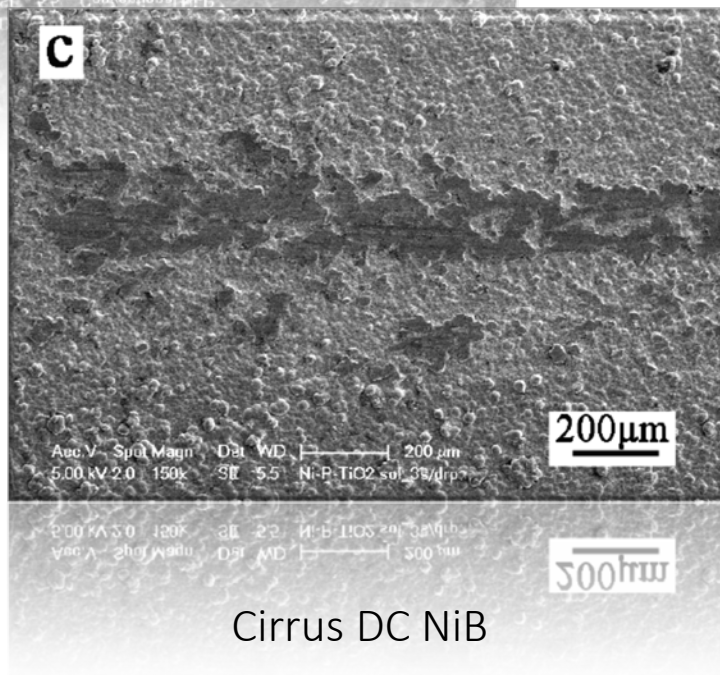
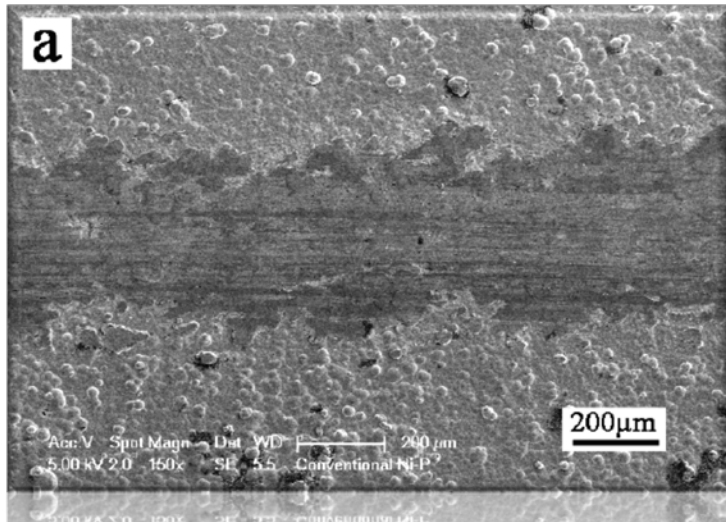
Process	Dopant	Nano-particles	Coatings
<ul style="list-style-type: none"><li>• Electroless</li><li>• DC Plating</li><li>• Pulse Plating</li></ul>	<ul style="list-style-type: none"><li>• Aqueous</li><li>• Organic</li><li>• Inorganic</li></ul>	<ul style="list-style-type: none"><li>• Ti</li><li>• Zr</li><li>• Al</li><li>• Zn</li><li>• Yr</li><li>• Si</li></ul>	<ul style="list-style-type: none"><li>• Au</li><li>• Ag</li><li>• Sn</li><li>• Cu</li><li>• Zn</li><li>• Ni</li><li>• NiB</li><li>• NiCo</li><li>• NiP</li></ul>

cirrus Broadened Application beyond Au

... all with industry partners ...

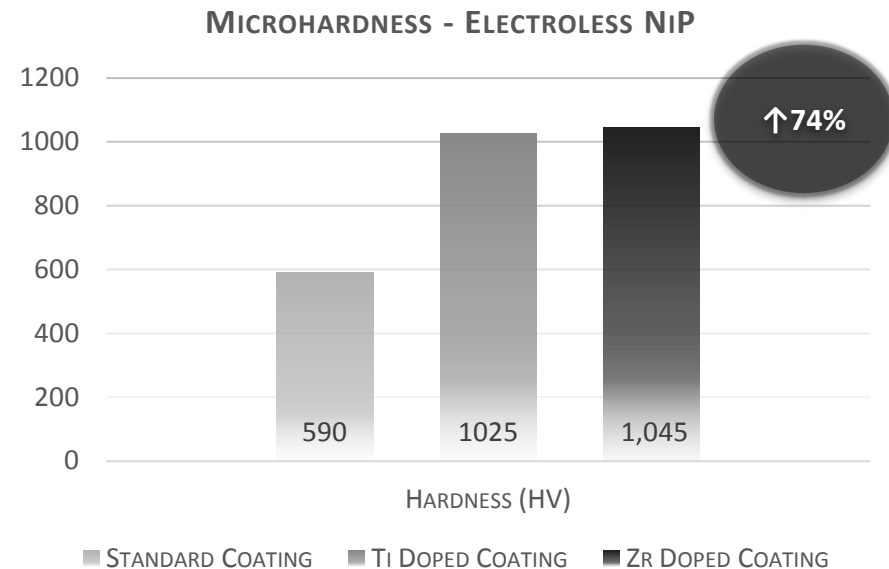
... all with commercial baths formulations.

Standard DC NiB



Cirrus DC NiB

cirrus wear resistance



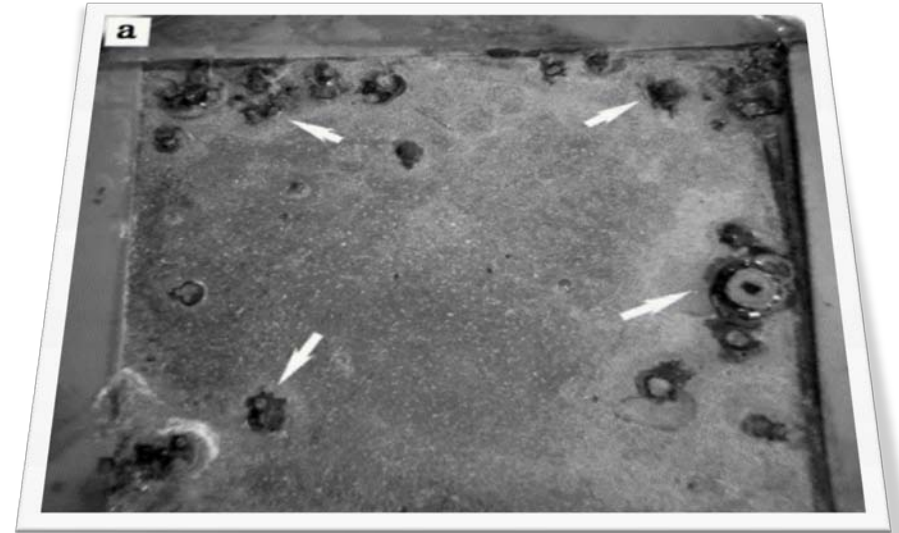
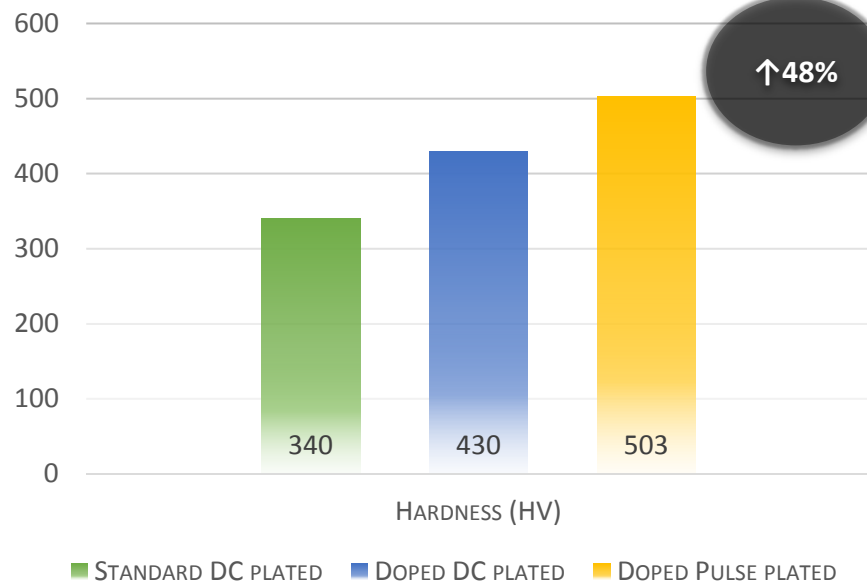
15 microns Electroless Nickel Phosphorus  
versus **cirrus** Zr nano-composite Nickel  
Phosphorus on Magnesium



## cirrus corrosion resistance

15 micron duplex Nickel versus **cirrus** Ti nano-composite Nickel on Mild Steel

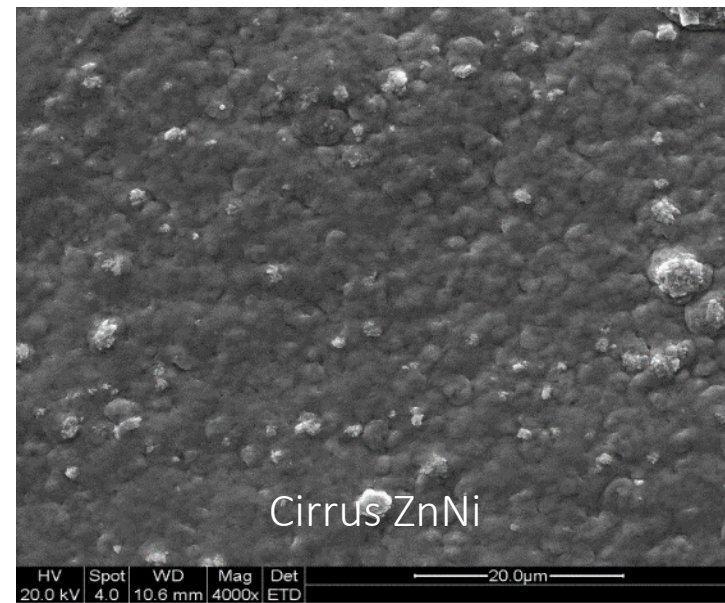
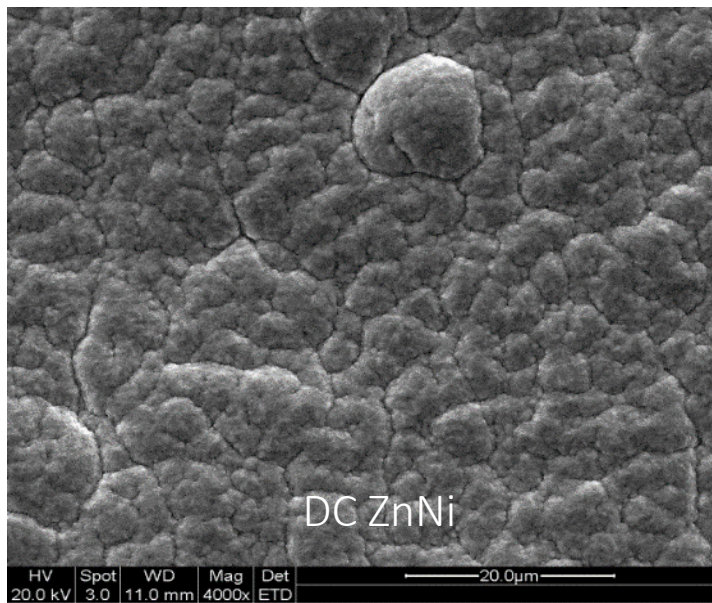
MICROHARDNESS - ELECTROPLATED NICKEL



Duplex Ni



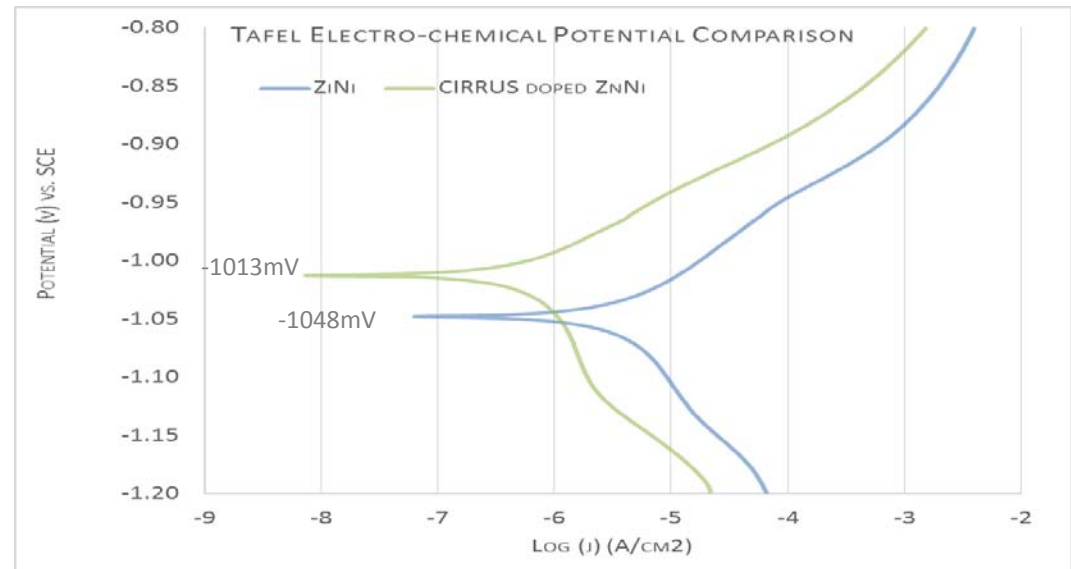
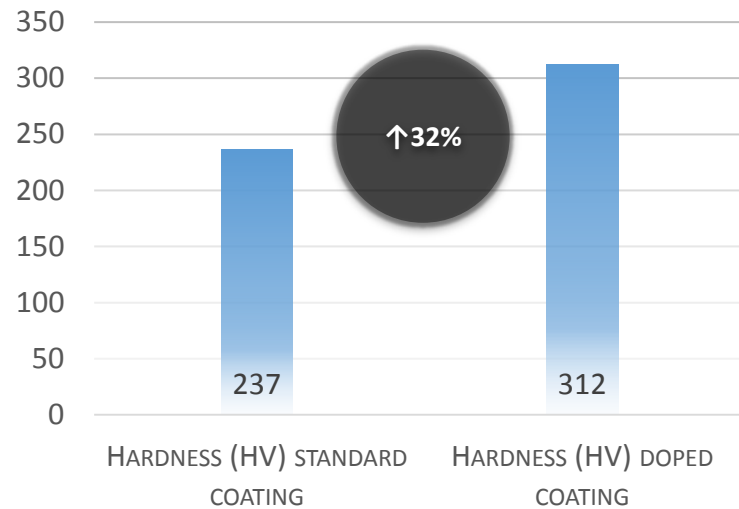
Cirrus Ti doped Ni



## ZnNi

10 micron ZnNi versus **cirrus** Al nano-composite ZnNi on Mild Steel

### MICROHARDNESS - ELECTROPLATED ZN NI







# Current Test Applications





- Harder, stronger plated coatings across wide range of materials
- Creates potential to substitute less costly coatings, or produce longer lasting coatings.
- Fine with heat treatments – some increase in thermal stability
- No change in coating functionality (corrosion resistance, conductivity etc.) or appearance.

cirrus nano-composite coatings



# Summary

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- Low volume, simple, drop in additive to existing plating process
- Softer coatings become more durable – hard coatings get harder
- Potentially changes performance expectations of wide range of electroless & electrolytic coatings
- New technology – focus is on niche applications where Cirrus can have impact
- Early stage – seeking industry partners for co-development

# Thank you

Glen Slater, Cirrus Materials

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